International Journal of Surgery 9 (2011) 150–154

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.theijs.com

Single-incision laparoscopic-assisted surgery for colon cancer via a periumbilical approach using a surgical glove: Initial experience with 9 cases

Hideyuki Ishida*, Norimichi Okada, Keiichiro Ishibashi, Tomonori Ohsawa, Kensuke Kumamoto, Norihiro Haga

Department of Digestive Tract and General Surgery, Saitama Medical Center, Saitama Medical University, 1981 Kamoda, Kawagoe, Saitama 350-8550, Japan

ARTICLE INFO

Article history:
Received 21 September 2010
Accepted 2 October 2010
Available online 25 October 2010

Keywords:
Colectomy
Colon cancer
Single incision
Laparoscopy

ABSTRACT

Our initial experience of performing a single-incision laparoscopic-assisted (SILS) colectomy using a "home-made" multichannel port system is presented. Nine patients (5 women) with a median age of 67 years (range, 55–72 years) and a median body mass index of 21.2 kg/m^2 (range, 17.8–26.7 kg/m^2) underwent the SILS colectomy for colon cancer between September 2009 and March 2010. The sites of the primary tumor were the ascending colon ($n = 2$), hepatic flexure ($n = 1$), transverse colon ($n = 2$), and sigmoid colon ($n = 4$). Each trocar was introduced intraperitoneally through each finger of a surgical glove attached to the wound protector, which was applied to a midline fasciotomy made via a $^3/_4$-circular periumbilical incision. If necessary, one to three radial splits were added to the incision. The colon was mobilized intracorporeally, and the vessels were ligated intra- or extracorporeally. All the patients underwent a curative segmental colectomy without conversion to a standard multiport laparoscopy or open surgery. The median operative time and blood loss were 140 min (range, 135–165 min) and 50 mL (range, 20–225 mL), respectively. The median number of harvested lymph nodes was 18 (range, 6–31). The pathological stages included stage 0 ($n = 2$), stage I ($n = 6$), and stage III ($n = 1$). The median number of postoperative analgesic use was one (range, 0–6). No intra- or postoperative complications occurred in this series. Our SILS colectomy procedure seems feasible and safe in selected patients with colon cancer.

1. Introduction

Laparoscopic-assisted surgery is associated with fewer postoperative complications, shorter hospital stay, faster recovery of bowel function, and less incidence of wound infection compared with conventional open surgery in patients undergoing colorectal resection.[1–5] Moreover, the oncological safety of laparoscopic-assisted surgery in patients with colon cancer has been proven in several randomized trials.[6–9] Even with these advantages, many surgeons have tried to decrease the number of ports used during laparoscopic procedures to achieve better cosmesis, less pain, and less risk of subsequent incisional hernia. Therefore, single-incision laparoscopic-assisted surgery (SILS), also known by other names such as single-port access surgery and laparoendoscopic single-site surgery, has drawn attention and has been used for colon resection as well as other abdominal procedures, such as cholecystectomy,[10,11] appendectomy,[12] and urological procedures.[13] However, limited case series of SILS colectomy for colon cancer have been reported in the literature,[14–18] and the method of performing SILS colectomy seems to vary among laparoscopic surgeons. We began to perform SILS colectomy for colon cancer using a "home-made" multichannel port system and a periumbilical approach using a surgical glove. This paper describes in detail our surgical techniques as well as the results obtained from our initial experience.

2. Patients and methods

This series consisted of 9 patients who underwent the SILS colectomy via a periumbilical incision for the resection of colon adenocarcinoma between September 2009 and March 2010. All the patients were selected to undergo the described procedure based on their body build (body mass index < 27 kg/m^2) and tumor status. The diagnosis of colon cancer was made based on a histological examination of biopsy specimens obtained during a colonoscopic examination. The depth of invasion (T-category)[19] was evaluated comprehensively based on a barium enema and colonoscopic findings. Abdominal computed tomography was performed to determine the presence of metastasis to the lymph node(s) (N-category),[19] liver, and distant organs. The tumor status indicated for the procedure was a preoperative diagnosis of T1(T2)

* Corresponding author. Tel.: +81 49 228 3619; fax: +81 49 222 8865.
E-mail address: 05hishi@saitama-med.ac.j (H. Ishida).

1743-9191/$ – see front matter © 2010 Surgical Associates Ltd. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijsu.2010.10.010

N0 tumor according to the TNM classification.[19] All the patients gave their informed consent after learning the details of the surgical technique, possible complications, and the chance of conversion to a standard multiport laparoscopic or conventional laparotomy.

All surgical procedures were performed using a "home-made" multichannel port system by a single surgical team, which included two operating surgeons (NO and HI).The surgeon and the camera operator stood on the right side of the patient during sigmoid colon cancer surgery and on the left side of the patient during transverse colon or ascending colon cancer surgery. The assistant stood on the opposite side from the surgeon. The patient was placed on the operating table in a supine position with broad base of the thigh. A $^{3}/_{4}$ -circumferential skin incision was made at the border of the umbilicus, usually 5–10 mm from the center of the umbilicus. Furthermore, the incision was made on the left side of the umbilicus for sigmoid colon cancer surgery, on the right side for right colon cancer surgery, and cephaladly for transverse colon cancer surgery. In other words, the ¼-circumference was left intact on the opposite side of the tumor. The peritoneal cavity was encountered after making a 5–6 cm incision. A wound retractor (Alexis™, medium size; Applied Medical, Santa Margarita, CA, USA) was placed on the edge of the abdominal incision and covered with a surgical glove. After setting the pneumoperitoneum to 10 mmHg, two 5-mm trocars for laparoscopic instruments and a 12-mm trocar for the laparoscope were introduced intraperitoneally through each finger of the surgical glove. The laparoscope used in one case was a conventional 10-mm type with a 30-degree angle; the laparoscope used in the remaining 8 cases was a 5-mm or 10-mm type with a flexible tip (HD Endo EYE™; Olympus Medical Systems, Tokyo, Japan). A Ligasure™ device (Covidien, Mansfield, MA, USA) and conventional (straight) laparoscopic forceps and graspers were used for all the laparoscopic procedures (Fig. 1). There was no need for the surgeon's hands to be crossed, and specific articulated laparoscopic instruments were not required. Instead, we used the gravitational effect of the operating table angle to maneuver the colon and small intestines when necessary. The lateral-to-medial technique was used to mobilize the sigmoid colon. Lateral-to-medial mobilization was also performed for right-sided colon cancer, with some modifications by dividing the gastrocolic ligament first, followed by releasing the hepatic flexure and then dissecting Told's fascia downward. After full mobilization of the colon (Fig. 2), the site distal or proximal from the cancer on both sides of the lesion were transected extracorporeally, followed by lymph node dissection under direct vision (Fig. 3) using conventional surgical and/or laparoscopic instruments for cancers of the sigmoid colon, ascending colon, or the hepatic flexure. The laparoscopic division of the mesenteric vessels preceded the bowel transection for the transverse colon cancer. The level of lymph node dissection and the extent of bowel resection were determined according to the therapeutic guidelines for colorectal cancer in Japan[20]; Limited lymph node dissection including the removal of the epicolic, paracolic, and intermediate lymph nodes (D2-level)[21] was performed for all the preoperatively (or intraoperatively) diagnosed T1(T2)N0 cancers. Specifically, the inferior mesenteric artery was divided on the distal side at the level where the left colic artery branched off to the sigmoid colon. The ileocolic and right colic vessels (if present) were isolated and divided at their origins without removal of the fat tissue around the superior mesenteric vessels for the ascending colon cancer. The roots of the right colic vessels were ligated and

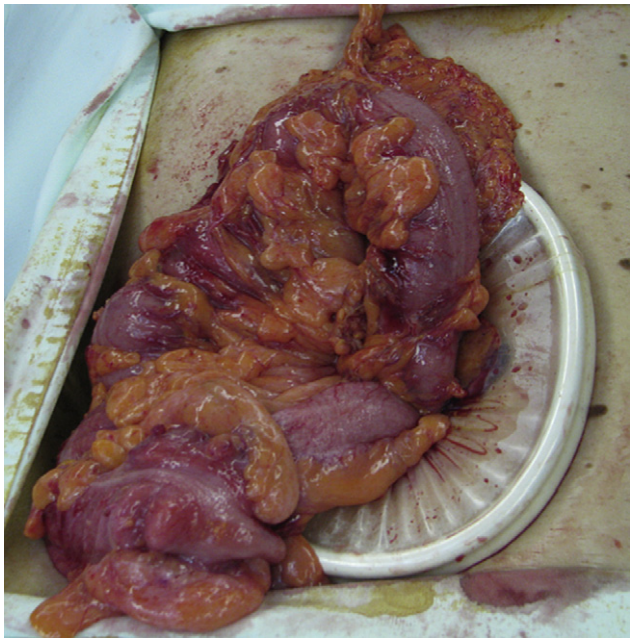

Fig. 2. Operative photograph showing the extraction of the specimen (right colon).

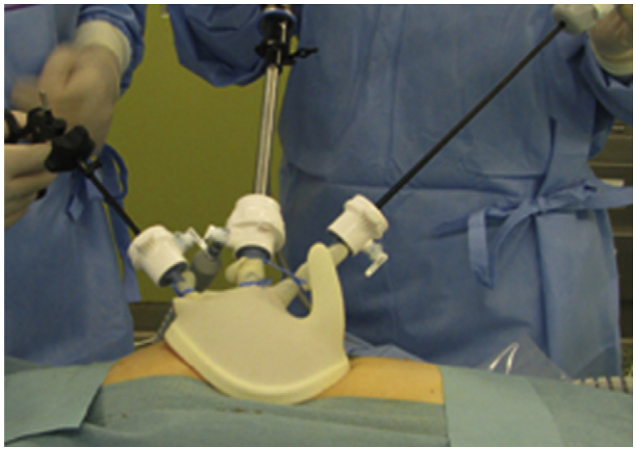

Fig. 1. Operative photograph showing the "home-made" multichannel port setting with multiple trocars and instruments.

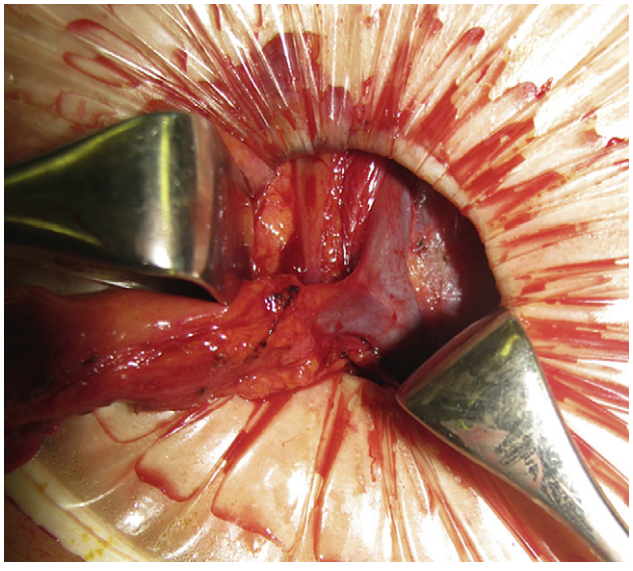

Fig. 3. Operative photograph showing the superior mesenteric vein and the ileocolic vein exposed during lymph node dissection.

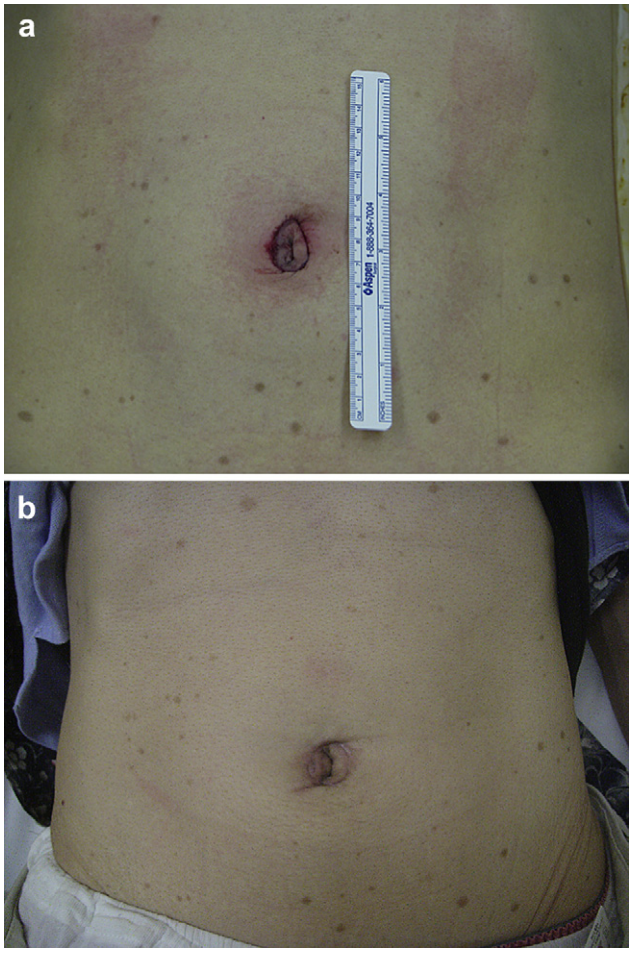

Fig. 4. (a) Surgical wound around the umbilicus at the end of the operation. (b) Incision scar on postoperative day 30.

divided for cancer of the hepatic flexure due to the blood supply to the tumor. The middle colic vessels were isolated and divided laparoscopically without dissecting around the superior mesenteric vessels for the transverse colon cancer. The bowel resection was extended at least 10 cm proximally and 10 cm distally from T2 cancer, and at least 5 cm proximally and 5 cm distally from Tis/T1 cancer. A stapled anastomosis was performed extracorporeally. When the surgeon felt that it would be difficult to perform the lymph node dissection under direct vision and/or to perform the anastomosis safely, one to three 5-mm long radial splits were added to the periumbilical incision to widen the "surgical window". The peritoneum was closed with interrupted absorbable sutures, and the skin was closed using subcuticular sutures (Fig. 4a). When one to three radial splits were added to the periumbilical incision, the skin was trimmed to adapt the skin incision straight to the border of the umbilicus.

3. Results

The patient characteristics are shown in Table 1. The patients' median age was 67 years (range, 55–72 years). The male:female ratio was 4:5. The median body mass index was 21.2 kg/m^2 (range, 17.8–26.7 kg/m^2). According to the American Society of Anesthesiology (ASA) classification, there were 6 class I and 3 class II patients. Three patients had undergone previous abdominal surgery (hysterectomy, appendectomy, and laparoscopic cholecystectomy). The sites of the tumors were the ascending colon ($n=2$), hepatic flexure ($n=1$), transverse colon ($n=2$), and sigmoid colon ($n=4$). In one case, SILS colectomy was performed as an additional surgery for a histologically confirmed T1-tumor[19] with lymphatic invasion after endoscopic resection. The preoperatively (or intraoperatively) diagnosed tumor status (T-category)[19] of the other 8 cases was T1 for 7 cases and T2 for one case. The SILS colectomy via the periumbilical approach using a surgical glove was successful in every patient. Three patients required a radial 5-mm long split, and one patient required three 5-mm long splits to extend the wound to avoid bowel congestion and allow a safe anastomosis. The types of colectomy performed were a right colectomy ($n=2$), a transverse colectomy ($n=2$), a sigmoidectomy ($n=4$), and other segmental colectomy ($n=1$). The median operative time was 140 min (range, 135–165 min), and the median blood loss was 50 mL (range, 20–225 mL). No intraoperative or postoperative complications occurred in this series. The median length of the resected specimen was 18 cm (range, 12–37 cm). The median number of lymph nodes harvested was 18 (6–31). The pathological staging according to the TNM classification[19] included stage 0 ($n=2$), stage I ($n=6$), and stage III ($n=1$). The median number of postoperative analgesic use (pentazocine, 15 mg/body, by intramuscular injection) was 1 (range, 0–6). The median postoperative length of the hospital stay was 8 days (range, 8–10 days). After a median follow-up period of 9.4 months (range, 5–12 months), no recurrences or wound complications have occurred (Fig. 4b).

4. Discussion

SILS colectomy poses a number of unique challenges for the laparoscopic surgeon. Triangulation and retraction are significantly limited. The use of a laparoscope and several instruments parallel

Table 1
Characteristics of patients.

Case	Age (Years)	Sex	BMI (kg/m^2)	ASA	Previous abdominal surgery	Tumor location	Operative time (min)	Blood loss (mL)	Number of radial split (s)	Length of resected specimen (cm)	Number of lymph nodes harvested	pTNM
1	66	Male	19.1	I		Sigmoid	165	60		18	20	T1N0M0
2	55	Male	26.7	I	Laparoscopic cholecystectomy	Sigmoid	135	185		14	12	T1N0M0
3	58	Male	22.4	I		Transverse	140	225		15	12	T1N0M0
4	72	Female	19.4	I	Hysterectomy	Transverse	137	70		37	27	TisN0M0
5[a]	68	Male	22.8	II		Sigmoid	155	40	3	14	5	T1N0M0
6	59	Female	22.2	I		Hepatic flexure	135	20	1	12	18	TisN0M0
7	67	Female	17.8	II		Ascending	168	50	1	20	19	T1N0M0
8	69	Female	21.2	II		Sigmoid	135	30		25	11	T3N1M0
9	70	Female	18.7	I	Apendectomy	Ascending	163	50	1	25	31	T1N0M0

[a] Additional surgery after endoscopic mucosal resection.

to each other results in a decreased range of motion and the "clashing" of instruments, rendering lymph node dissection difficult to perform safely in cases of cancer. In addition, the technical complexity of the operation may result in a significant learning curve for performing SILS. Furthermore, the need to develop new, specialized instrumentation may result in an unfavorable balance of cost-effectiveness. Compared with previously reported SILS colectomy, our method has several special characteristics.

We have confirmed satisfactory cosmetic results similar to those obtained using a transumbilical approach by making a periumbilical skin incision within the confine of the umbilicus. In SILS colectomy, the surgeon usually requires a transumbilical incision of 2.5–5 cm in length,[14–18,22–24] through which a laparoscope and several laparoscopic instruments are inserted intra-abdominally. The transumbilical scar has been reported to be invisible vertically, but it is not completely hidden in the umbilicus in some cases.

Our "home-made" multichannel port system provided a satisfactory working space sufficient to minimize the "clashing" of laparoscopic instruments without requiring any SILS specific techniques or instruments, and enabling an extracorporeal anastomosis to be performed safely. Although we have not compared our "home-made" port system with other commercially available SILS ports, our system seems to have a drawback in terms of the stability of the ports. Rubber gloves do not provide any means of stabilization. Nonetheless, our port system is definitely low cost, and the limited stability of the ports can easily be overcome by the surgeon's manual skills. Since the area of the "surgical window" seems to depend on the total length of the periumbilical incision, in patients with a relatively short distance between the center of the lesion and the border of the umbilicus and/or an abundance of mesenteric fat, several radial splits to the periumbilical incision were necessary to avoid bowel congestion and to allow an easy and safe extracorporeal anastomosis. Specifically, if a 5-mm long radial split was added, the length of the periumbilical incision was extended by 10 mm. This modification to the skin incision actually became invisible outside the confine of the umbilicus after trimming.

Lymph node dissection was performed under direct vision through the small incision after full mobilization in patients with cancer of the sigmoid colon, the ascending colon, and the hepatic flexure. Before the development of SILS colectomy, we performed curative colectomy via a minilaparotomy (skin incision ≤ 7 cm)[25–27] for more than 280 cases, using conventional surgical instruments as a minimally invasive alternative to the standard laparoscopic approach. Based on our experience with the minilaparotomy approach, we did not have any difficulties to perform lymph node dissection around the inferior mesenteric artery or the surgical trunk via the small incision, though the required level of lymph node dissection was limited because of the tumor stages in this series. However, based on our experience with SILS colectomy and minilaparotomy, we feel that a standard lymph node dissection around the inferior mesenteric artery or superior mesenteric vessels is feasible if the patient is not extremely obese. We divided the middle colic vessels when performing a transverse colectomy because the distance between the umbilicus and the root of the middle colic artery is relatively long, leading to potential hazards for lymph node dissection under direct vision. Many laparoscopic surgeons prefer the medial-to-lateral approach for laparoscopic curative colectomy. It may be advisable, from an oncological point of view, to ligate and divide vessels laparoscopically using the medial-to-lateral technique. However, to the best of our knowledge, evidence to support an actual survival benefit of the "laparoscopic no-touch isolation technique" seems to be somewhat scarce.

In this series, the SILS colectomy was feasible and safe. No excessive delays in the operative time occurred, and the blood loss was acceptable. The cosmetic results were also favorable, though the follow-up periods remain rather short. In terms of postoperative pain, the number of analgesic use also seems to have been acceptable. One of the benefits of SILS may be a shorter hospital stay. While the median postoperative length of the hospital stay (8 days) may be somewhat long, Japanese patients tend to demand longer hospital stays than those recommended by their surgeons to ensure recovery to their preoperative status. Moreover, the patients' family members also strongly support a longer hospital stay. These were the reasons for the longer hospital stay in this series.

Oncologic safety is a prerequisite for applying this procedure to the treatment of colon cancer. In this series, we limited the indications for this procedure to preoperatively (intraoperatively) diagnosed T1(T2)N0 cancers. We confirmed that the number of lymph nodes harvested and the length of the resected specimen were adequate. Careful case selection and a longer follow-up would be needed to confirm the oncologic safety of this procedure. In addition, expanding the indications for our SILS colectomy to tumors of a more advanced stage requiring standard lymph node dissection including the main lymph nodes will be challenging and deserves further investigations.

In conclusion, our SILS colectomy seems to be feasible, safe, and favorable for early cosmetic results. Further experience is needed to validate the usefulness of the procedure. In addition, the oncologic safety of the procedure will need to be determined. To address these questions, prospective randomized controlled trials comparing our SILS technique and multiport laparoscopic or minilaparotomy approaches may be required.

Conflict of interest
None to declare.

Funding
None to declare.

Ethical approval
None to declare.

References

1. Ng SS, Leung KL, Lee JF, Yiu RY, Li JC, Hon SS. Long-term morbidity and oncologic outcome of laparoscopic-assisted anterior resection for upper rectal cancer: ten-year results of a prospective, randomised trial. *Dis Colon Rectum* 2009;**52**:558–66.
2. Kennedy GD, Heise C, Rajamanickman V, Harms B, Foley EF. Laparoscopy decreases postoperative complication rates after abdominal colectomy: results from the national surgical quality improvement program. *Am Surg* 2009;**249**:596–601.
3. Poon JT, Law WL, Wong IW, Ching PT, Wong LM, Fan JK, et al. Impact of laparoscopic colorectal resection on surgical site infection. *Am Surg* 2009;**249**:77–81.
4. Law WL, Lee YM, Choi HK, Seto CL, Ho JW. Impact of laparoscopic resection for colorectal cancer on postoperative outcomes and survival. *Ann Surg* 2007;**245**:1–7.
5. Senagore AJ, Duepree HJ, Delaney CP, Brady KM, Fazio VW. Results of a standardized technique and postoperative care plan for laparoscopic sigmoid colectomy: a 30-month experience. *Dis Colon Rectum* 2003;**46**:503–9.
6. Jayne DG, Guillou PJ, Thorpe H, Ouirke P, Copeland J, Smith AM, et al. Randomised trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC classic trial group. *J Clin Oncol* 2007;**25**:3061–8.
7. Lacy AM, Delgado S, Castells A, Prins HA, Arroyo V, Ibarzabal A, et al. The long-term results of a randomised clinical trial of laparoscopy-assisted versus open surgery for colon cancer. *Ann Surg* 2008;**248**:1–7.
8. Fleshman J, Sargent DJ, Green E. Clinical outcomes of surgical therapy study group. Laparoscopic colectomy for cancer is not inferior to open surgery based on 5-year data from the COST study group trial. *Ann Surg* 2007;**246**:655–62.
9. Leung KL, Kwok SP, Lam SC, Lee JF, Yiu RY, Ng SS, et al. Laparoscopic resection of rectosigmoid carcinoma: prospective randomized trial. *Lancet* 2004;**363**:1187–92.
10. Piskun G, Rajpal S. Transumbilical laparoscopic cholecystectomy utilizes no incision outside the umbilicus. *J Laparoendosc Adv Surg Tech A* 1999;**9**:361–4.
11. Rao PP, Bhagwat SM, Rane A, Rao PP. The feasibility of single port laparoscopic cholecystectomy: a pilot study of 20 cases. *HPB (Oxford)* 2008;**10**:336–40.
12. Rispoli G, Armellino MF, Esposito C. One-trocar appendectomy. *Surg Endosc* 2002;**16**:833–5.
13. Kouk JH, Haber GP, Goel RK, Desai MM, Aron M, Rackley RR, et al. Single-port laparoscopic surgery in urology: initial experience. *Urology* 2008;**71**:3–6.

14. Ramos-Valadez DI, Patel CB, Ragupathi M, Pickron TB, Haas EM. Single-incision laparoscopic right hemicolectomy: safety and feasibility in a series of consecutive cases. *Surg Endosc* 2010;**24**:2613–6.
15. Law WL, Fan JKM, Poon JTC. Single-incision laparoscopic colectomy: early experience. *Dis Colon Rectum* 2010;**53**:284–8.
16. Boni L, Dionigi G, Cassinotti E, Gliuseppe MD, Diurni M, Rausei S, et al. Single incision laparoscopic right colectomy. *Surg Endosc*; 2010; doi:10.1007/s00464-010-1100-4.
17. Rieger NA, Lam FF. Single-incision laparoscopically assisted colectomy using standard laparoscopic instrumentation. *Surg Endosc* 2010;**24**:888–90.
18. Uematsu D, Akiyama G, Matsuura M, Hotta K. Single-incision laparoscopic colectomy with a novel multiport device in sigmoid colectomy for colon cancer. *Dis Colon Rectum* 2010;**53**:496–501.
19. International Union Against Cancer In: Sobin LH, Gospodarowicz M, Wittelkind C, editors. *TNM classification of malignant tumors*. 7th ed. New York: Wiley-Blackwell; 2010. p. 100–5.
20. Japanese Society for Cancer of the Colon and Rectum. *JSCCR guidelines for the treatment of colorectal cancer*. Kanehara, Tokyo: Japanese Society for Cancer of the Colon and Rectum; 2010 [in Japanese].
21. Japanese Society for Cancer of the Colon and Rectum. *Japanese classification of colorectal carcinoma*. 2nd English ed. Kanehara, Tokyo: Japanese Society for Cancer of the Colon and Rectum; 2009.
22. Remzi FH, Kirat HT, Geisler DP. Laparoscopic single-port colectomy for sigmoid cancer. *Tech Coloproctol* 2010;**14**:253–5.
23. Merchant AM, Edward L. Single-incision laparoscopic right hemicolectomy for a colon mass. *Dis Colon Rectum* 2009;**52**:1021–4.
24. Choi SI, Lee KY, Park SJ, Lee SH. Single port laparoscopic right hemicolectomy with D3 dissection for advanced colon cancer. *World J Gastroenterol* 2010;**16**:275–8.
25. Ishida H, Nakada H, Yokoyama M, Hayashi Y, Ohsawa T, Inokuma S, et al. Minilaparotomy approach for colonic cancer: initial experience of 54 cases. *Surg Endosc* 2005;**19**:316–20.
26. Ishida H, Ishiguro T, Ohsawa T, Okada N, Yokoyama M, Kumamoto K, et al. Curative colectomy via minilaparotomy approach without utilizing specific instruments. *Tech Coloproctol* 2010;**14**:153–9.
27. Ishida H, Ishiguro T, Ishibashi K, Ohsawa T, Kuwabara K, Okada N, et al. Impact of prior abdominal surgery on the curative resection of colon cancer via a minilaparotomy approach. Surg Today, in press.